HEAT EXCHANGER HAVING PROJECTING FLUID PASSAGE

CROSS REFERENCE TO RELATED APPLICATION

This application is based upon Japanese Patent Application No. 2002-270545, filed on September 17, 2002, the contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention:

The present invention relates to an exhaust gas heat exchanger in which an internal fluid passage is formed by using plate-like members.

Related Art:

A Japanese Laid-open patent application No. 2001-41678, now which is matured to U.S. Patent No. 6,401,804, discloses a heat exchanger, such as the one described above, which is formed by only using plural heat-transmitting plates defining an inside fluid passage without using a fin member such as a corrugated fin. In this heat exchanger, plural flat-sectional tubes, each of which is composed of two aluminum plates fixed to one another to have inside-fluid passages, are disposed adjacent with one another so that space for air passage is formed between adjacent tubes to perform heat exchange between the air flowing through the space and inside fluid flowing inside the tubes.

Also, U.S. Patent No. 5,195,240 (corresponding to Japanese Patent No. 2966427) discloses a fin-less heat exchanger which is made from resin material. In this heat exchanger, a header

portion and fluid passage are formed therein by attaching two resin sheets.

In the former heat exchanger, it is composed of aluminum, and therefore, it is relatively heavy. To reduce its weight, the thickness of each plate should be thinned. The thinned plate is effective in view of heat exchange. At the same time, a problem might arise when the thinned plate is employed as follows.

A tank portion and the inside-fluid passages are integrally formed from a single plate by a press forming process. The tank portion has an area for receiving pressure larger than that of the inside-fluid passage. Therefore, it might be difficult to obtain sufficient withstanding pressure strength at the tank portion when the thickness of the plate is thinned. To solve this problem, additional parts should be required to reinforce the tank portion.

On the other hand, the latter has relatively light weight. However, as described above, the problem regarding the thickness at the tank portion and the heat exchange portion still remains because the tank portion and the inside-fluid passage portion are formed by attaching two resin sheets.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a heat exchanging component having relatively light weight and capable of optimizing the thickness of a tank portion and the thickness of a heat exchanging portion.

According to a first aspect of the present invention, a heat

exchanging component has a heat transmitting plate composed of resin material. Moreover, a tank portion and an inside-fluid passage portion are integrally formed in the heat transmitting plate.

Preferably, the thickness of the heat transmitting plate at the tank portion and the thickness of the heat transmitting plate at the inside-fluid passage portion are different. For example, the thickness of the heat transmitting plate at the tank portion is relatively thick while the thickness of the heat transmitting plate at the inside-fluid passage portion is relatively thin. This feature can be obtained by forming the heat transmitting plate by an injection molding process.

Other features and advantages of the present invention will become more apparent from the following detailed description made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1A is a disassembled perspective view of a heat exchanger according to a first embodiment of the present invention;

Fig. 1B is a partial cross sectional view showing the coolant passages in the first embodiment of the present invention;

Fig. 2A is a partial cross-sectional view of a heat transmitting plate member at a tank portion in first embodiment of the present invention;

Fig. 2B is a partial cross-sectional view of heat

transmitting plates at a heat exchanging portion before being attached together in the first embodiment, and

Fig. 2C is a partial cross sectional view of a heat transmitting plate member at a heat exchanging portion in the first embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Specific embodiments of the present invention will now be described hereinafter with reference to the accompanying drawings in which the same or similar component parts are designated by the same or similar reference numerals.

A first preferred embodiment of the present invention will now be described with reference to Figs. 1A, 1B, and 2A-2C. In this embodiment, an evaporator 10, which is typically employed, for example, as a refrigerant evaporator for a vehicle air conditioner, is provided as a perpendicular-flow type heat exchanger in which a stream direction A of conditioning air is approximately perpendicular to a stream direction B (an up-down direction in Fig. 1A) of refrigerant flowing in a heat-transmitting plate member 12.

The evaporator 10 has a core portion 11 for performing a heat-exchange between the conditioning air (i.e., outside fluid) and the refrigerant (i.e., inside fluid), which is formed by plural heat-transmitting plate members 12 disposed adjacent with one another. Each heat-transmitting plate member 12 is formed as a pair of plates by combining a first heat-transmitting plate 12a with a second heat-transmitting plate 12b as shown in Figs.

1A and 2A-2C.

Each of the heat-transmitting plates 12a and 12b is made of resin material such as nylon-based material, and is formed by an injection molding process to have a thickness t approximately in a range of 0.1-0.4 mm at fluid passage 19 or 20. As shown in Fig. 1A, each of the heat-transmitting plates 12a and 12b is approximately formed into a rectangular shape to have the same outer peripheral dimension. For example, the rectangular shape has a longitudinal length of about 240 mm, and a lateral width of about 45 mm.

The molding form of the plate 12a may be basically the same as that of the plate 12b. It may be different when the form of the coolant passage is complex. Namely, the basic form of the plate 12a is not necessarily the same as that of the plate 12b.

As shown in Fig. 2B or 2C, plural projection ribs 14 are formed on the respective plates 12a and 12b so as to project from the respective flat base plate portion 13. Moreover, each projection rib 14 has a contour of substantially a trapezoidal shape and has substantially a semicircular sectional inside shape. In addition, a pair of fitting convex portions 14a is formed on a side opposite to the projection ribs 14 in each plate 12a, 12b so that the pair of fitting convex portions 14a of one of plates 12a and 12b fits to the one of the projection ribs 14 of the other of plates 12a and 12b to form the coolant passage 19 or 20. In this embodiment, the shape between the fitting convex portions 14a in the pair is substantially semicircular. Therefore, when combining the plate 12a with 12b by attaching respective base

plate portion 13 as shown in Figs 2B and 2C, the refrigerant passage 19 or 20 is defined to have substantially an annular cross-sectional shape by the semicircular inside shape of the projection rib 14 and the semicircular shape formed between the fitting convex portions 14a in the pair as shown in Fig. 2C. Each projection rib 14 extends in a direction parallel to a longitudinal direction of the heat-transmitting plate member 12, i.e., in a direction perpendicular to an air flowing direction A. Moreover, each projection rib 14 is arranged parallel with others. In each of the first and second heat-transmitting plates 12a, 12b, three projection ribs 14 are arranged in an upstream side of air and a downstream side of air, respectively. Therefore, six refrigerant passages are defined at the upstream side and the downstream side in one plate member 12, respectively, by attaching the plates 12a, 12b togather.

More specifically, the refrigerant passages 20 are arranged at the upstream side with respect to a center in the width direction of the plate member 12, while the refrigerant passages 19 are arranged at the downstream side with respect to the center in the width direction. Figs. 1B, 2B and 2C only shows the upstream-sided refrigerant passages 20 or downstream-sided refrigerant passages 19.

Tank portion 15-18 are formed in each heat-transmitting plate member 12 at both ends thereof in a direction perpendicular to the air-stream direction A in Fig. 1. The two tank portions 15, 17 and 16, 18 are formed in the respective end as shown in Fig. 1. The tank portions 15, 17 at one end of each

heat-transmitting plate member 12 and tank portions 16, 17 at the other end are divided (or arranged) in a direction parallel to the air-stream direction A, respectively. The tank portions 15-18 project to the same direction as that of the projection ribs 14 as shown in Figs. 2A and 2B. Moreover, the height of each tank portion is the same as that of the projection ribs 14.

As shown in Fig. 2A, each tank portion is thicker than the base plate portion 13, in a cross-sectional direction, i.e., an up-down direction in the figure, to increase the ability to withstand pressure. For example, the thickness of each tank portion is approximately 2 mm.

A fitting-connect portion 12c is formed in the tank portions 15-18 at a contact surfaces in both side in a laminated (disposed) direction so as to have sealing characteristic improved and have connecting strength improved when attaching the plates 12A and 12B together. As shown in Fig. 2A, a convex portion of a fitting-connect portion 12c formed in the plate 12a meets with a concave portion of a fitting-connect portion 12c formed in the plate 12b when fixing together in range with the projecting direction of the projection ribs 14.

The refrigerant passages 20 in the upstream side communicate with the tank portion 17 and 18 at the respective end, while the refrigerant passages 19 in the downstream side communicate with the tank portion 15 and 16 at the respective end.

The tank portions 15, 17 and tank portions 16, 18 are arranged at the respective end of the plate member 12 in the direction parallel to the air-stream direction A as shown in Fig.

1. Each tank portion has an oval shape in a width direction of the plate member 12. Each tank portion 15, 16, 17, or 18 has a communicating hole 15a, 16a, 17a, or 18a, which can allow the adjacent plate members 12 to communicate with one another therethrough in the laminating direction.

Namely, as shown in Fig. 2A, the communication between the respective communicating holes 15a-18a is secured when the attaching surface in each tank portion is attached together with that of the other tank portion formed in the adjacent plate member 12. The projection ribs 14 formed in one plate member 12 are provided at locations shifted from that of the projection ribs 14 formed in the adjacent plate members 12 so that each projection rib 14 can face a convex portion defined by the base plate portion 13 in the adjacent plate members 12 as shown in Fig. 1B.

As a result, space is formed between the projection ribs 14 and the base plate portion 13 to have an undulance shape when disposing the plate members 12 adjacent together by attaching the fitting-connect portions 12c formed in the adjacent plate members 12. With this shape of the space, the air can meanderingly pass between the adjacent plate members 12 along with a direction shown with an arrow A1 as shown in Fig. 1B.

Next, a portion regarding an inlet and an outlet for the refrigerant passage of the core portion 11 will be described with reference to Fig. 1A. End plates 21 and 22, each of which has a size substantially equal to that of the heat-transmitting plate member 12, and side plates 25 and 31 are provided at both ends in a disposing direction of the heat-transmitting plate members

12, respectively. Each end plate 21, 22 has a flat shape so that top portions of the projection ribs 14 and tank portions 15-18 are attached to a surface thereof.

The end plate 21, which is shown in the left side of the figure, has a refrigerant inlet hole 21a provided in a location near a lower end thereof, which is in communication with the communicating hole 15a of the tank portion 15 positioned at a lower end of the plate member 12 in the downstream side of the air-stream, and a refrigerant outlet hole 21b provided in a location near an upper end thereof, which is in communication with the communicating hole 18a of the tank portion 18 positioned at an upper end of the plate member 12 in the upstream side of the air-stream.

The end plate 22, which is shown in the right side of the figure, has a refrigerant inlet hole 22a provided in a location near a upper end thereof, which is in communication with the communicating hole 16a of the tank portion 16 positioned at a upper end of the plate member 12 in the downstream side of the air-stream, and a refrigerant outlet hole 22b provided in a location near an lower end thereof, which is in communication with the communicating hole 17a of the tank portion 17 positioned at a lower end of the plate member 12 in the upstream side of the air-stream.

In this embodiment, a refrigerant inlet pipe 23 and a refrigerant outlet pipe 24 are collectively assembled in a duct joint block 30 as a single duct connecting member so that the connection between the evaporator 10 and external refrigerant

pipes can be simple. Therefore, as shown in Fig. 1A, a refrigerant passage is formed between the end plate 21 and side plate 31 so as to communicate with the refrigerant inlet and outlet in the duct joint block 30 by attaching the end plate 21 and the side plate 31 together.

More specifically, projection ribs 31a are formed in the side plate 31 from a portion of the duct joint block 30 toward the lower portion of the side plate 31 so as to project outward. All the projection ribs 31a are connected with each other at their top and bottom ends. However, each projection portion 31a is independent of one another in the middle of the side plate 31 (in the figure, three projection ribs 31a are provided), so that the strength of the side plate 31 is increased by increasing its section modulus.

An upper end portion of a refrigerant passage formed by concavity formed inside of the projection ribs 31a is in communication with the refrigerant inlet pipe 23 in the duct joint block 30. A lower end portion of the refrigerant passage in the projection ribs 31a is in communication with the communicating hole 21a of the end plate 21. Also, the refrigerant outlet pipe 24 communicates with the communicating hole 21b in the end plate 21.

Similar to the heat-transmitting plate member 12, the end plates 21, 22 and side plates 25, 31 are made from resin material such as nylon-based material. These plates have a plate thickness thicker than that of the plate member 12 at a thickness t of approximately 1.0 mm so as to improve the strength. Also, the

duct joint block 30 is made from resin material such as nylon-based material by an injection molding process to have the refrigerant inlet pipe 23 and outlet pipe 24 integrally formed. The duct joint block 30 is attached to the side plate 31 by adhering the connecting portions thereof.

In this embodiment, gas-liquid two phase refrigerant decompressed in a decompressing unit such as an expansion valve (not shown) in a refrigeration cycle flows into the refrigerant inlet pipe 23, while the refrigerant outlet pipe 24 is connected to a suction side of a compressor (not shown) so that gas refrigerant evaporated in the evaporator 10 is introduced into the suction side of the compressor.

In each heat-transmitting plate member 12, a refrigerant passage 19 disposed in the downstream side constitutes an inlet-side refrigerant passage in an entire configuration of the evaporator 10 since the refrigerant flows into it from the refrigerant inlet pipe 23, while the refrigerant passage 20 disposed in the upstream side constitutes an outlet-side refrigerant passage in the entire configuration of the evaporator 10 since the refrigerant, which has flown through the refrigerant passage 19 in the downstream side (inlet side), flows out therefrom to the refrigerant outlet pipe 24.

Next, an entire passage of the refrigerant in the evaporator 10 will be described. First, the tank portions 15 and 16, which are located in the downstream side, constitute a refrigerant inlet-side tank member among the tank portions 15-18 disposed at top and bottom ends of the evaporator 10. On the other

hand, the tank portions 17 and 18, which are located in the upstream side, constitute a refrigerant outlet-side tank member. The gas-liquid two phase refrigerant decompressed in the expansion valve flows into the inlet-side tank portion 15 located at the bottom end in the downstream side from the refrigerant pipe 23 through the refrigerant inlet pipe 23. Then, the refrigerant comes up toward the inlet-side tank portion 16 at the top end through the refrigerant passages 19 formed by the projection ribs 14 arranged in the downstream side in each plate member 12. The refrigerant collected at the inlet-side tank portion 16 flows into an inner space of the side plate 25 through the refrigerant outlet hole 22a of the end plate 22. Next, the refrigerant comes down in the inner space as a communication path, and then, flows into the outlet-side tank portion 17 at the bottom end in the upstream side from the refrigerant inlet hole 22b of the end plate 22. After that, the refrigerant comes up toward the outlet-side tank portion 18 at the top end through the refrigerant passages 20 formed by the projection ribs 14 arranged in the upstream side in each plate member 12. The gas refrigerant evaporated in the evaporator 10 is sucked into the suction side of the compressor from the refrigerant outlet pipe 24.

In this embodiment, the refrigerant passage is defined as described above. The evaporator 10 is assembled by laminating the members (or parts) described above sequentially by attaching the contact surfaces of the members using adhesive such as epoxy resin.

The evaporator 10 is installed in an air-conditioning unit

case (not shown) in such a manner that an up-down direction of the evaporator 10 corresponds to the up-down direction in Fig. 1A. Air is blown by operation of a blower unit (not shown) in a direction shown by an arrow A in Fig. 1A. When the compressor of the refrigerant cycle operates, gas-liquid two-phase refrigerant at a lower pressure side, which is decompressed in the expansion valve, flows into the evaporator 10 along with the refrigerant passage described above.

On the other hand, the air passage is formed by the space defined with the projection ribs 14 and base plate portion 13 entirely in the width direction of the plate member 12 (air-stream direction A) so as to have a meandering flow shape shown as the arrow A1 in Fig. 1B.

As a result, the air blown in the direction of the arrow A meanderingly passes between the adjacent plate members 12 like the arrow A1. The air is cooled down while passing the evaporator since the refrigerant is evaporated by absorbing an evaporation-latent heat from the air passing through the space between the adjacent plate members 12.

In this operation, by providing the inlet-side refrigerant passages 19 at the downstream side and providing the outlet-side refrigerant passages 20 at the upstream-air side with respect to the air-flowing direction A, the inlet and the outlet of the refrigerant is disposed in a countercurrent arrangement with respect to the air-stream. Moreover, the air-flowing direction A is approximately perpendicular to the longitudinal direction (i.e., the refrigerant-flowing direction B in the refrigerant

passage 19, 20) of the projection ribs 14 in the heat-transmitting plate members 12. Further, each of the ribs 14 has an outer convex protrusion surface (heat-transmitting surface) protruding in a direction perpendicular to the air-flowing direction A. Thus, air is restricted from linearly flowing due to the outer convex surface of the projection ribs 14.

Thus, the flow of the air passing through the spaces between the heat-transmitting plate members 12 is meandering so as to be disarranged, thereby becoming a turbulent flow. Accordingly, heat-transmitting effect is greatly improved. It is true that heat-transmitting area between the air passing through the space and the heat-transmitting plate members 12 is greatly reduced without fins being provided to the heat-transmitting members 12. However, sufficient cooling performance can be obtained in this embodiment because the effect caused by the reduction of the heat-transmitting area can be compensated with the improvement of the heat-transmitting rate in the air side by causing the turbulent flow of the air.

According to the first embodiment, the heat-transmitting plate members 12 (12a, 12b) are made from the resin material. Therefore, the evaporator 10 can have a light weight. The tank portion (15-18) has a thickness thicker than that of a portion where the refrigerant passage 19 or 20 is formed.

This configuration can be obtained easily by employing method such as the injection molding process in which different thickness in different portions in a single part can be obtained with a forming die.

By using the advantages of the injection molding process, the plate member can be formed in such a manner that the optimal thickness can be obtained in every point in a single molding part so that, for example, the portion corresponding to the refrigerant passage 19 or 20 is relatively thin so as to have a good performance of heat exchange, and the tank portions 15-18 is relatively thick where the withstand pressure strength is required high.

The heat-transmitting plate member 12 has the base plate portion 13. Moreover, the heat-transmitting plate member 12 has the refrigerant passages 19, 20, which project outwardly with respect to the base plate portion 13, and has a trapezoidal outer surface and a circular inner surface at a cross-section.

This configuration also can be obtained relatively easily by the injection molding process by using the advantages thereof in which each portion can have its own necessary shape. Therefore, the outer shape of the projection ribs 19, 20 can have the trapezoidal shape which is highly effective in a heat-transmitting rate, while having the circular shape in the inner surface thereof which is advantageous to have the necessary ability to withstand pressure. Therefore, different optimal shapes can be easily obtained in the different portions in the single plate member 12.

The pair of fitting convex portions 14a is used to form the refrigerant passage 19 or 20, which fits with an inner side of each projection rib 14. Even if the fitting convex portions 14a are not formed, the plate 12a and plate 12b can be attached to

form the plate member 12. However, it is desirable to have the convex portions 14a for forming the refrigerant passage 19 or 20 with the projection rib 14 to improve the connecting strength. With the fitting convex portions 14a, the force applied to the connection can be shifted to shearing stress, and therefore, the connecting strength can be improved. The fitting convex portions 14a also can be easily obtained by using the advantages of the injection molding process described above.

Also, the fitting-connect portion 12c can improve the connecting strength at the connecting surfaces of the tank portions 15-18 because, as described above, the force applied to the connection can be shifted to shearing stress. The fitting-connect portions 12c also can be easily obtained by using the advantages of the injection molding process described above.

Among parts constituting the evaporator other than the heat-transmitting plate members 12, the end plates 21, 22 and the side plates 25, 31 (also joint block 31) are made from resin material. It is effective to reduce its weight. Moreover, the parts are assembled by using the adhesive, and therefore, the assembly process can be simplified because a heating process is not necessary. The heating process is required in the soldering process in the conventional type. Also, the power to assemble the parts to form the evaporator can be reduced.

Although the heat-transmitting plates 12a and 12b are formed distinctly in the injection molding process, and attached together after being formed, these plates 12a and 12b can be formed as a single piece in the injection molding process, so that

the single piece has two heat-transmitting plate portions (like 12a, 12b) which are connected with one another by a jointing portion made of the resin material which can be folded or removed when attaching the two heat-transmitting plate portions together

Although the evaporator which has the air-stream direction A perpendicular to a refrigerant-flow direction (the longitudinal direction of a plate member 12) B is described in the above-mentioned embodiment, the perpendicular arrangement is not so important in this invention. In sum, the air-stream direction A is just to have a relationship with the refrigerant-flow direction B so as to cross with one another at the predetermined angle.

Although the present invention is applied to the evaporator 10 in the above-described embodiment in which the low-pressure refrigerant for the refrigerant cycle flows in the refrigerant passages 19 and 20 in the heat-transmitting member 12, and the air flows outside of the heat-transmitting member 12, the present invention is not limited to the above-described embodiments. The present invention will be utilized in, for example, a general heat exchanger in which heat-transmission is conducted between inside fluid and outside fluid in several usages. To ensure the refrigerant route in the evaporator, the plate configuration, duct or pipe connecting configuration or the like also can be modified in such a manner that an artisan in this technical field can appreciate the invention.

While the present invention has been shown and described with reference to the foregoing preferred embodiment, it will be

apparent to those skilled in the art that changes in form and detail may be therein without departing from the scope of the invention as defined in the appended claims.